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Original Contributions

UTILIZATION AND YIELD OF CHEST COMPUTED TOMOGRAPHIC ANGIOGRAPHY ASSOCIATED WITH LOW POSITIVE D-DIMER LEVELS

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□ **Abstract—Background: It is unclear to what degree broadly applied D-dimer testing combined with a low threshold for imaging with even minimally positive results may be contributing to the utilization of chest computed tomographic angiography (CTA). Study Objectives: To determine what proportion of chest CTAs for suspected pulmonary embolism (PE) were performed in the setting of minimally elevated D-dimer levels, and to determine the prevalence of PE in those patients when stratified by clinical risk. Methods: Retrospective chart review of all patients who had chest CTA for the evaluation of suspected PE during the years 2002–2006 in a suburban community teaching hospital emergency department. Results: There were 1136 eligible patient visits, of which 353 (31.1%) were found to have D-dimer levels in the low positive range (0.5–0.99 μg/mL). Of these 353 patients, 9 (2.6%; 95% confidence interval [CI] 0.9–4.2%) were diagnosed with PE. There were also 109 patients (9.6%) who had normal D-dimer levels (<0.5 μg/mL). Two of these 109 (1.8%; 95% CI 0–4.2%) were diagnosed with PE. When stratified by the Pulmonary Embolism Rule-out Criteria, 99 of 353 patients with low positive D-dimer levels (28.0%; 95% CI 23.4–32.7%), and 14 of 109 with normal D-dimer levels (12.8%; 95% CI 6.6–19.1%) were classified as low risk, none of whom had PE. Conclusions: Nearly one-third of all chest CTAs were done for patients with minimally elevated D-dimer levels, and another 9.6% for patients with normal D-dimer levels with very low yield. Further research to define clinical criteria identifying patients with minimal risk of PE despite low positive D-dimer levels represents an opportunity to improve both patient safety and utilization efficiency of chest CTA. © 2012 Elsevier Inc.**

□ **Keywords—pulmonary embolism; D dimer; chest CT angiography; clinical risk; Pulmonary Embolism Rule-out Criteria**

INTRODUCTION

Over the last decade, the advent of blood D-dimer testing combined with chest computed tomographic angiography (CTA) has greatly refined the diagnostic evaluation of patients with suspected pulmonary embolism (PE). Current clinical guidelines recommend that patients with suggestive symptoms and positive D-dimer levels have imaging studies to establish a definitive diagnosis, whereas normal D-dimer levels combined with low or intermediate clinical risk are sufficient to rule out PE (1–12). Most authors agree that patients at high risk for PE proceed to imaging studies regardless of the D-dimer level (1–12). Since originally described by Remy-Jardin in 1996, chest CTA has largely replaced ventilation/perfusion (V/Q) lung scanning in patients with normal renal function based on overall superior sensitivity and specificity for pulmonary embolism as well as the ability to provide

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diagnostic information about other conditions (13–20). V/Q scanning remains the study of choice for those with contrast dye allergy and renal insufficiency.

D-dimer levels, however, are very non-specific with regard to PE (3,6). Although D-dimer testing is a valuable tool to prevent the missed diagnosis, clinical experience suggests that broadly applied highly sensitive D-dimer testing combined with a low threshold for imaging with even minimally positive results may be driving increased demand for imaging studies without increasing the diagnostic yield for PE (21,22). This may be particularly true of patients with D-dimer levels in the low positive range, especially those with low clinical risk (23,24).

Kline et al. assert that "the over investigation of low-risk patients with suspected pulmonary embolism represents a growing problem" (25). In their study of over 8000 patients from 13 hospitals, diagnostic testing for PE was ordered in 67% of patients who clinicians considered low risk and a full 80% of patients for whom alternative diagnoses were considered more likely (25). Le Gal and Bounameaux state that "the progressive decrease in the proportion of confirmed cases (of pulmonary embolism) among suspected patients … has resulted in an important cost-efficacy unbalance in the diagnostic strategies based on D-dimer testing, as the proportion of patients with positive D-dimer but without pulmonary embolism increases dramatically" (22). They also state that the "increasing acceptance of modern non-invasive diagnostic strategies along with medicolegal concerns has led clinicians to an over-testing for pulmonary embolism … leading to a cost-efficacy unbalance" (22).

The dramatic increase in CT scan utilization over the last 15 years is well documented and has been increasingly recognized as a significant source of radiation exposure. The increased demand for imaging is also a major driving force in medical inflation (26–30). Hillman and Goldsmith note that "these costs were the fastest growing physician-directed expenditures in the Medicare program, far outstripping general medical inflation" (28).

We sought to quantify the proportion of chest CTA utilization associated with minimally elevated D-dimer levels and to determine the yield of chest CTA in those patients. We then applied clinical risk criteria to determine if low clinical risk within this group of patients accurately identified those who did not have PE.

MATERIALS AND METHODS

This study was approved by the institutional review board by expedited review with waiver of informed consent.

The study is a retrospective chart review. A sequential sample of all emergency department (ED) patients who had chest CTA performed to rule out PE during the 5-year period from 2002 to 2006 was selected.

Chest CTA was performed on GE "Lightspeed" four-slice CT scanners from January 2002 through February 2005, and GE "Lightspeed" 16-slice scanners after February 2005 (GE Healthcare, Chalfont St. Giles, UK). Images were obtained using standardized technique with timed intravenous pump infusion of contrast 5–10 s before imaging. Images were obtained with 1.25- or 2.5-mm collimation, depending on the CT scanner used. All scans were read by board-certified radiologists.

The D-dimer assay used during the study period was the Asserachrome D-Di (Stago International, Parsippany, NJ), a rapid quantitative enzyme-linked immunosorbent D-dimer assay with normal range of < 0.5 μg/mL (< 500 ng/mL).

Study Setting and Population

Newton-Wellesley Hospital is a 224-bed suburban community teaching hospital and is a member of the Partners Health Care System, Inc., a consortium of eight acute care hospitals in the metropolitan Boston area that includes Massachusetts General Hospital and Brigham and Women's Hospital. During the years 2002–2006, the hospital had 23 acute care ED beds, with an average yearly ED census of 44,425 patient visits.

Patients were identified by cross-referencing computerized radiology logs of all chest CTAs done at this institution for the years 2002–2006 with "ED" for patient location and "ED attending" as the ordering physician. Inclusion criteria were all ED patients having chest CTA for the reasons "rule out PE," "dyspnea/shortness of breath," or "chest pain/rule out PE." Exclusion criteria included chest CTA for any reason other than those specifically stated in the inclusion criteria, such as "trauma," "chest pain/rule out aortic dissection," or "evaluate mass." If the reason for a chest CTA was unclear, the ED record for that visit was reviewed by the primary author (DSH) to determine the purpose of the chest CTA. Patients were also excluded if chest CTAs were canceled or if results were not available. Pregnant patients are not included in this sample as the imaging technique of choice in pregnancy during the time frame of this study was V/Q scan. Chest CTAs and D-dimer levels were included only if performed during the patient's index ED visit.

Definitions and Outcome Measures

The primary outcome measures were the number of chest CTAs for patients with low positive D-dimer levels, the prevalence of PE in those patients, and the prevalence of PE in the low-clinical-risk subgroup of those patients.

Pulmonary embolism was defined as the presence of one or more intraluminal filling defects or abrupt vessel cut-offs in the pulmonary vascular tree, and results were